CENTER FOR VIRTUAL PROVING GROUND SIMULATION

Center for Virtual Proving Ground Simulation: Mechanical and Electromechanical Systems

The University of Iowa and the University of Texas at Austin

A National Science Foundation Industry/ University Cooperative Research Center since 1997

Virtual prototyping reduces mechanical system development time and improves product quality

Center Mission and Rationale

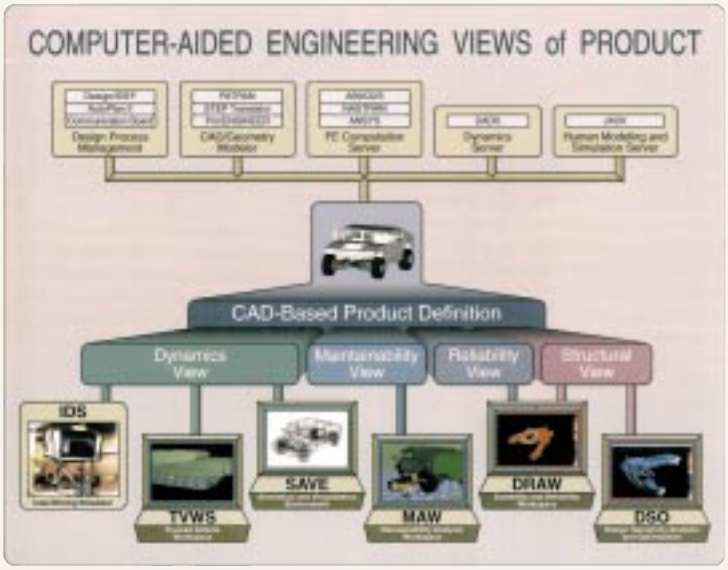
Powerful, stand-alone computer-aided engineering (CAE) and analysis tools are broadly used in industry by specialists from various disciplines. New methods are being developed by the Center for Virtual Proving Ground Simulation: Mechanical and Electromechanical Systems to enable these tools to function in an integrated, concurrent engineering environment to support large-scale mechanical system development. The Center advances basic technologies in mechanical system dynamic simulation, durability and reliability analysis, maintainability analysis, structural design optimization, and real-time operator-in-the-loop simulation methods and software, and it creates an integrated multidisciplinary virtual prototyping software environment.

Research Program

The Center's basic technical objectives are to develop—

- ***Dynamic simulation methods for broad classes of mechanical and electromechanical systems***. The Center has developed high-speed recursive dynamics formulations that can achieve real-time simulation on parallel processor computer systems.
- ***Virtual prototyping capabilities to support the design of human-operated equipment.*** The Center utilizes real-time, operator-in-the-loop simulation to place the operator directly in control of a high-fidelity, dynamic simulation of the system under design with realistic cueing feedback. This revolutionary new capability allows designers to tune the design of equipment to the capabilities of the operator.
- ***Structural design sensitivity analysis (DSA) and optimization methods.*** The Center has developed linear and nonlinear structural design sensitivity analysis and optimization methods using finite element analysis results from ANSYS, MSC/NASTRAN, and ABAQUS. This capability enables optimization with respect to material properties, sizing, shape, and configuration design parameters that are defined using CAD and geometric modelers such as Pro/ENGINEER and PATRAN.
- ***Durability and reliability analysis methods for mechanical components.*** The Center has developed capabilities to predict component failure, based on fatigue crack initiation and propagation due to general nonproportional loading histories obtained from dynamic simulation. A component-level reliability analysis capability has been developed, based on simulation and prediction of multiple failure modes that result from general loading histories.
- ***Maintainability analysis.*** The Center has developed maintainability analysis methods and software to support the rapid assessment of maintainability, using computer models of maintenance personnel for mechanical systems and support equipment. The software helps the user identify design features that cause maintainability problems and propose design modifications to eliminate problems encountered during maintainability analysis.
- ***Methods to integrate engineering software tools in a broad range of mechanical system analysis, design, and manufacturing disciplines.*** The Center has developed an integrated concurrent engineering environment that allows engineers from various disciplines to collaborate effectively. This environment supports design data sharing, design process management, distributed computation, and design trade-off analysis.

The Center believes that performing pilot research projects with its sponsors is the most effective means of focusing on key problems that must be solved to create a virtual prototyping capability that meets industry needs. Since its inception, the Center has carried out pilot projects related to military and commercial vehicles and construction equipment. These pilot projects have been augmented by major research projects sponsored by the Department of Defense's Advanced Research Projects Agency



(ARPA), the Defense Modeling and Simulation Office (DMSO), and the U.S. Department of Transportation (DOT).

The goal of one special joint project with ARPA is to develop a virtual prototyping-based concurrent engineering environment for ground vehicles. The US Army Tank-Automotive Command (TACOM) and several military vehicle industrial firms are participating in this project. The project focuses on virtual prototyping for system acquisition and is demonstrating the feasibility of supporting vehicle system acquisition using soldier-in-the-loop simulation. Operator-in-the-loop simulation of wheeled and tracked vehicles with an engineering level of realism has been created, and databases suitable for off-road military vehicle simulation with the soldier-in-the-loop have been developed and demonstrated.

The Center has carried out special joint projects with a number of industries. One project with Ford Motor Company, for example, involved the development of DSA capabilities for dynamic frequency response for noise, vibration, harshness (NVH) suppression that are now in use by Ford engineers.

Special Center Activities

The Center has developed dynamic simulation and structural optimization software that is used by a number of Center members and is also being commercialized. Real-time dynamic simulation capabilities developed by the Center have established the feasibility of virtual prototyping-based design of complex mechanical systems and enabled development of the nation's most advanced ground vehicle driving simulator, the Iowa Driving Simulator (IDS), which is available for Center member use. The real-time simulation technology was also the foundation for a Department of Transportation (DOT) project that is creating the world's most advanced ground vehicle driving simulator, called the National Advanced Driving Simulator (NADS). This world-class facility will be acquired by the DOT, located at The University of Iowa, and operated in cooperation with the Center. The Center has collaborated with many other I/UCRCs and universities.

Iowa Driving Simulator

Driving the simulator

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